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ABSTRACT

This essay provides commentary on the place of mathematics in the study and practice of educational administration. The incidence of mathematical topics in the writing of the field is explored, and their isolation from each other and from the body of literature is pointed out. Possible areas of synthesis are sought from the traditional use of mathematical models as tools all the way to emerging ideas involving mathematical metaphors and styles of thinking. Extensive footnotes are included. (Author/TE)

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Marjorie K. Hanson

Mathematics and Administration: Tools, Metaphors and Styles of Thinking

This essay provides some commentary on the place of mathematics in the study and practice of educational administration. The incidence of mathematical topics in the writing of the field is explored and their isolation from each other and from the body of literature is pointed out. Possible areas of synthesis are sought from the traditional use of mathematical models as tools to emerging ideas involving mathematical metaphors and styles of thinking.

Marjorie K. Hanson is Assistant Professor in the Department of Educational Organization, Administration and Policy at the State University of New York at Buffalo.

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MATHEMATICS AND ADMINISTRATION:
TOOLS, METAPHORS, AND STYLES OF THINKING

The public relations director seemed distraught as she reflected on the events of the meeting she had just had with a reporter. The local newspaper was going to do a story on the rise in tuition costs at the half dozen or so institutions of higher learning in the city, and, based on percentage increases, her institution was coming out looking pretty bad. However, it was true: at 40% increase over the past year's tuition, her small, blue collar, state-funded institution was far above even the prestigious private university whose tuition was increasing only 6%. She threw up her hands; what could she do in face of the "facts"?

In a state of great frustration, she approached the co-ordinator of research at her institution. The co-ordinator helped the public relations director appreciate that what both the administrator and the reporter had overlooked was the deceptive nature of percentages: they represent proportions and not absolute magnitudes. Thus, the very large proportion of increase from the public institution's very small base resulted in a very much smaller actual dollar increase than the private university's small proportionate increase from a very large base. When the public relations director realized this discrepancy between what seemed to be and what was, she called the reporter and tried to explain to him that a more balanced article would report the actual size of the tuition as well as the percentage increase for each institution.

What problem is posed by this ancedote for the instructional program in administration? Certainly it was not lack of ability to do simple arithmetic that prevented the public relations director from seeing the misinformation that was being communicated. Nor can we fault

her skill in budgeting or program planning. She had composed, proposed and administered budgets and publicity programs for several years as director of this vital component of the modern institution of higher education. She was also conversant in basic statistics, as the meeting with the researcher to plan the forthcoming student survey demonstrated. Would more statistical skill have enabled her to better address this situation involving a very rudimentary arithmetic process?

To me this illustration points up the need to better define the nature of mathematical experiences that we might incorporate in the preparation of educational administrators. There are a few institutions which focus more than others on the preparation of administrative specialists in research, planning and/or evaluation, those areas of administration most likely to be considered quantitative. Individuals so prepared as well as others quantitatively prepared outside of the area of administration and even of the field of education take positions as researchers, planners, evaluators--as support staff to the institutional administration. But where is the place of mathematics or quantitative methods in the program of the administrative generalist?

TOWARDS THE BEGINNING OF AN ANSWER

We shall in this paper suggest the bare outline of an answer to the above question. In doing so, it should be clear that the answer is partial, and represents more a plea for dialogue than a firm assertion. Furthermore, the direction I suggest in what follows is not a

reductionist one. That is, in searching for an appropriate analysis of the question, I am attempting to draw from many different sources for insight. To begin with, I shall reflect upon efforts of first generation mathematical modelers of the 70's; next I shall examine the world of theory qualitatively perceived and relate it to the more quantitative but less theoretical mode of research. I shall analyze a well-known text (used in educational administration) in each of these approaches to generate a search for what may be more useful terrain within which mathematical activity might be embedded.

In further pursuit of common ground, I will explore some writings within two classes which hue closer to the actual practice of administration: the works which attempt to translate the results of research into a technology to be practiced, and essays by scholars who have become practitioners which describe the utility of their scholarly learning in the field.

Finally, I explore a range of possible connections between the theory and practice of educational administration and the discipline of mathematics. The first part of this discussion touches on the traditional area of concrete application of quantitative tools. Next I move to some implications of the use of mathematics as metaphor in defining administrative issues. Finally, I search for some possible insights by explaining the recently emerging concept of mathematization within the field of mathematics education.

A VALIANT START AND A FIZZLE

In the early seventies there was a small cadre of individuals devoted to the application of complex mathematical models to problems in

educational administration. As these individuals moved into professorships, evidence of their interests appeared in scholarly publications,[1] workshops,[2] courses in quantitative methods, and a monograph put out by the University Council for Educational Administration describing the components of the quantitative portion of an educational administration program.[3] In the latter it was asserted that career opportunities for those who would specialize in such an area were to be found in the research and evaluation shops of large urban school districts, but the need for exposure to quantitative methods was not limited to those who would specialize in research. The general administrator confronted with the increased ability of computers to amass and analyze data would also find it helpful to be aware of how that data might be tamed for use in more informed decision making.

Something happened to this movement on the way to the eighties. It never burgeoned in colleges of education like it had in schools of management. While management became so obsessed with the training of technicians and the technical training of generalists (requiring a basic level of competency in mathematics and a certain amount of exposure to applied mathematics) that it took a "search for excellence" to point out that such skills have a limited role to play in the corporation,[4] the movement in educational administration seems to have gone out with a whimper. The foremost figures seem for the most part to have dispersed. Some are teaching statistics for educators, while others have joined the computer revolution and still others have joined (or returned to) the more traditional administrative fields of business or finance. But few can be found still struggling with the problem of applying mathematical

models or defining what there is about mathematical thinking that is central to administration.[5] At the 1981 meeting of the American Educational Research Association, for example, one leader in this area could be found presenting a method for teaching linear programming through a regression analysis framework; but he made no attempt to address, nor was he asked, what on earth use it was to learn linear programming.[6]

REFLECTIONS OF A SECOND GENERATION

I consider myself to be a second generation advocate of mathematics in administration, and I feel like I've inherited a quandary from my forebears. As is often the case, I was relatively untroubled until I began to teach a course in my "area of expertise." Having brought with me from my doctoral experiences a certain "messianic zeal," I eagerly rolled up my sleeves to spread the gospel of mathematical methods to a seminar of novices who were eager to become believers, but most of whom approached numbers with a large measure of trepidation. In the course, which was called "Basic Quantitative Techniques in Operations Analysis in Education," the students were exposed to and performed simple examples of certain traditional operations research techniques such as linear programming and simulation. The students and I were pleased that by the end of the semester not only did they have a grasp of some elementary mathematical applications, but they also had much more confidence in their ability to use and interpret numbers.

However, as I thought about future plans for the course, I was disturbed by a lack of unity among the topics which had been covered and perhaps more importantly by a lack of relevance between my course and

other courses in their program of study and the real world of educational administration. Like those who had preceded me in this endeavor, what I had was a variety of applications or likely applications. The truer, the more perfect the fit of the application the farther it seemed to be removed from the activities central to education. I had used a text written for business administration[7] and presented "school" examples related to busing, school lunch programs, marketing, etc. The most directly related examples seem to have to do with allocation and rewarding of personnel. Strive as we might, my students and I could not come up with examples which touch on our main interest--the education of children and adults. We found more examples which lend themselves to mathematical modeling in postsecondary settings, but this seemed to be mainly because those institutions are more similar to business in that competition is much more of a factor than in public schools. Still our applications didn't deal much with the function of education itself.

By the next time the course was offered, I had found a framework which I thought would help to solve the dilemma. Ebel[8] had suggested that the operations research framework might be a useful one for educational researchers to utilize. The elements of the framework that made it an attractive alternative to the traditional scientific method were (1) its tendency to thoroughly define a problem which had been identified in a particular setting and solve it for that setting and (2) its use of a variety of disciplines and technologies in coming up with a solution. Here was a frame which was indeed relevant and since all of the techniques which I taught fell under the traditional heading of

operations research, I felt that this also served to unify the topics. But, as I proceeded, I found that I was still impaled between the horns of the dilemma with which applied mathematicians in administration have long wrestled. Ebel claimed that the solution to an operations research problem in education need not be quantitative, but technically the model derived in an operations research problem, while it most likely will not be one of the traditional ones, tends to be (and some would say should be) mathematical and quantitative.[9] So how could I say you needn't quantify and still demonstrate the relevance of the mathematical techniques I was using?

There was clearly a need for me to step back further from the trees and attempt to define the role of mathematics in the forest of educational administration.

It seems to me that a possible cause for the state of affairs I find myself in is the nature of the first generation movement. The work of these pioneers opened up new possibilities for utilizing data to better inform decision making. They did this by discovering matches between real world decisions, available data, and applicable mathematical models.[10] They then promulgated these nice examples to the field through publishing their results and using them as case studies in teaching. But, aside from occasionally providing a map of examples,[11] they outlined no conceptual framework to support the marriage of mathematics to educational administration.[12] As a probable result, this area of study has not become an integral part of the study or practice of educational administration in the minds of practitioners or professors.

ONE SEARCH FOR A "HOME" FOR THE QUANTITATIVE: THEORY A NO-MATH LAND?

When we look at the works widely used in the preparation of administrators, we find a clear dichotomy between books dealing with the general theories and methods of administration and texts which introduce a "quantitative" or business approach. The puzzle is not so much that the dichotomy exists but that the differences are so marked. From the topics that are covered and the references cited, one has trouble relating them to the same field. Yet they are both addressed to the same audience: those individuals who aspire to educational administration. Wherein lies the unity of the field? Does the responsibility for finding that unity rest on the shoulders of students and practitioners? The authors of books don't seem to provide it.

Take two prominent examples, one from each category: Silver's recent Educational Administration: Theoretical Perspectives on Practice and Research as an example of the first type, and Hentschke's classic Management Operations in Education as an example of the second class.[13] A perusal of the extensive references in each book reveals one which appears in both books and an additional three authors who are cited in both books but for different works.[14] Now there may be perfectly good explanations for this. From the titles we can observe that Silver's book offers "theoretical perspectives" while Hentschke is dealing with "operations." Yet we would expect that there be some overlap and, in fact, Hentschke opens several of his chapters with sections entitled "theoretical foundations."

More significantly, we find the authors announcing their intentions and their foci in their respective prefaces, and we find those foci to appear distinctly different. Silver selects

> ...12 theoretical frameworks that appear to have profound relevance to practice and research in the profession of educational administration. Admittedly, the selection is a limited one, emphasizing sociology and social psychology more heavily than other behavioral or social science disciplines....[15]

On the other hand Hentschke selects from the "techniques and principles developed" within the fields of accounting, operations research, economics, and computer and information science.[16] With such diverging foci, frameworks for viewing as opposed to tools for doing, as well as the differences in sources of knowledge, we could hardly expect that there be any overlap of topics or citations. But perhaps this only serves to underline the dichotomy in the field which seems to revolve around the two poles of mathematical vs. non-mathematical.[17]

What is the nature of this dichotomy which is evidenced in the almost total disparity of citations? Silver uses models, tables, and graphic representations to illustrate the relationships between variables posited by the various theories, but stops short of the actual use of formulas or numbers. Books of the type represented here by Silver can frequently be classified as purely theoretical and lacking in an attempt to address or design a technology applicable to the specific business of schools: learning. However, Silver consistently relates each theory she presents to "enhancing student learning outcomes" by exploring implications of that theory to relevant aspects of the goal. With that effort she firmly ties the scientific theories to areas where administrative technology could be enhanced.

"QUANTITATIVE METHODS": THEORYLESS?

Turning to Hentschke, we see no dearth of formulas and numbers, but do we find mathematics herein? Texts and courses in the category which Hentschke represents are frequently denoted "quantitative" rather than mathematical.[18] Hentschke's terms include analysis, quantitative, operations, management, business and the like. He uses a familiar rationale for defending this class of quantitative books or "techniques." It boils down to: Now that education has become a large, centralized enterprise, we need to know how to run it like big business; therefore, we need to learn the quantitative methods developed by and used for analysis of large business operations. So here are some examples of how these methods have been applied in schools.[19] Note how operational or practical this justification sounds. Hentschke also harks back to Taylor's scientific management without addressing the serious criticism which the application of that technology to schools received in Callahan's Education and the Cult of Efficiency which appeared in the '60s.[20]

In a few of his chapters Hentschke includes a section on "theoretical foundations." These turn out to be descriptions of the methods and the specialized vocabulary which precede sections which describe examples of use. He justifies familiarity with the techniques outlined in the book by pointing out that administrators need to make many decisions, but he never deals with decision theory nor illustrates how these methods will influence the making of decisions. In short, discussion of theory tends to be touched only lightly in the type of educational administration book represented by Hentschke.

The apparent absence of theory in and of itself, however, is not enough to explain the lack of references in common with Silver. She does reach into the area of technology and Hentschke's technologies do arise from theory. So it is conceivable that some of their citations could overlap. However, Hentschke's technologies do not arise out of the social science theories explored by Silver and conversely the technology impact suggested by Silver are not the technologies discussed by Hentschke. It is as though the two authors are not writing in the same field, and perhaps they are not. As was noted earlier, Silver relates each of the theories she describes to the central focus of schools: student learning. Hentschke, on the other hand, draws all of his examples from ancillary functions of schools: transportation, food service, budgeting, personnel, maintenance, etc., operations differing little from those of any other business.

DO THE TWAIN EVER MEET?

There is a story of a psychologist who often found himself discovering commonalities between opposing points of view in his research and scholarly writing. When he focussed his insights on himself to try to discover why this was true of his work when so many other scholars seem to stress dissection and differentiation, he recalled an unusual characteristic of his childhood. When he was three years old, his father left home, and he was from then on raised by his mother and his paternal grandfather. He recalled being constantly in the role of mediator between these two starkly opposing individuals and apparently had continued such behavior throughout his professional life.

As a student and a teacher, it has always been appealing to me to bring things together. I suppose this is part of the reason that I find myself in a field rather than a discipline; I would rather examine theories as utilized in practice than in isolation from action. I also derive great satisfaction from trying to reduce the gulf between the so-called soft and hard sciences, perhaps between any seemingly opposing viewpoints.

Perhaps my tendency has similar roots to those of the psychologist. Whatever the cause for my predilection, I find myself believing that there would be some benefit to reducing the wide gulf between two strands of work in our field. Bringing the two viewpoints together showing respect for both, as opposed to taking sides and pointing out their differences, could result in healthy discussion of real issues for the administration of schools as well as for theory development.

It is often claimed that mathematics has wide applicability in other fields of study.[21] Perhaps the question here involves whether indeed mathematics has wide applicability to the general administration of educational institutions or whether it is only relevant to the business office and there only to the peripheral activities of schooling. Perhaps we can find some clue to the answer to this question by examining some places where the two points-of-view described above come together. Evidence of attempts to unify the field may be found in the occasional enlightened efforts of adherents of each perspective to span the gulf that divides them, in the attempts of management generalists to draw all aspects of the field into one unified

introductory overview, and in the reflections of administrators on the theories and techniques which they have found useful in the field.

The Theorists' Attempts.

The chapter in Silver which contains the one reference which overlaps with Hentschke is an interesting one. It contains discussion of the one theory of the twelve discussed by Silver that can be traced to an origin in the natural rather than the social sciences--Bertelanffy's General System Theory.[22] Of course, as Silver points out also, Bertelanffy himself branched out into other fields beyond his original area of biology, and General System Theory has been widely applied in the social sciences particularly by the sociologists whose extensions of the theory Silver explores. Here, however, we have a theorist (namely, Silver) picking up on a theory which originated in a more mathematical science and applying it to the administration of educational institutions, and herein we find the only citational evidence of unity between the books we chose as representative of the two diverse perspectives we find in the field's scholarship. Bertelanffy would undoubtedly be pleased that the General System Theory framework had served as a vehicle for an indication of unity.

While Silver calls the chapter discussed above "Organizational Process," she names the other chapter in this section on Whole Organizations "Organizational Structure." Here she discusses The Axiomatic Theory, beginning with a mathematical metaphor:

> Just as the notion of a geometric form, such as a triangle, can be imagined and diagramed though not directly perceived in reality, so the notion of organizational structure can be imagined and diagramed as the organizational chart though not directly perceivable in reality.[23]

In this chapter Silver cites axioms and corollaries which have been derived in accord with this theory. Here she also discusses such mathematical-sounding concepts as complexity, centralization, stratification, and efficiency.

The Mathematicians' Attempts.

In order to find attempts to bridge the gulf from this perspective, one needs to look outside the field of educational administration. Mitroff and Turoff's "The Whys Behind the Hows" offers an explication of the assumptions underlying the decision to apply one or another of several classes of mathematical techniques, thus tracing them to their philosophical bases.[24] Familiarity with such assumptions would serve to link techniques to their theoretical underpinnings and thus enable the thoughtful introspection provided by familiarity with the more pervasive sociological theories and encouraged in recent years by the example of the phenomenologists as they defend their more qualitative research methods.[25]

Attempts by Generalists Deriving a Technology.

Authors who undertake an outline of the technologies of administration for practitioners face the task of trying to relate what has been developed by theorists to real institutions which must be managed on a day-to-day basis. Since the two perspectives which we have outlined are not rectified in any thorough way by theorists, this must be done by the developer of a general technology in order to communicate a coherent prescription to the practitioner. An example of such a book is Drucker's Management. He treats what we have been calling the mathematical perspective within a section on Managerial Skills and what we have denoted the theoretical perspective in a section on Managerial Organization.[26]

Among managerial skills, Drucker includes the ability to utilize the tools available in the management sciences (our mathematical perspective), that is, to know when the services of persons skilled in that field would be of use. He asserts that the management sciences are grossly underutilized by today's managers and calls on management science to do a better job of developing as a science of management rather than a series of isolated examples.

In the theoretical section, Drucker describes three "generic dimensions" of organizations around which theoretical structures have been built.[27] None of these dimensions or their corresponding theoretical structures seem to embrace the mathematical perspective, but Drucker locates a fourth dimension around which a principle could have been formulated i.e. the decision. He thus provides a clue as to what the underlying theory which seems to be missing from the mathematical perspective should center on.

Thus, Drucker on the one hand calls on management science to do a better job of performing as a science to explain management and, on the other hand, implies that administrative theory might enlarge its borders so that it may encompass the mathematical models derived by management scientists. Such suggestions only serve to underline the need for the two perspectives to be somehow integrated.

Attempts by Scholar Practitioners.

Wilson's Management Science Applications to Academic Administration is a more balanced treatment of scientific approaches to administration than its name might imply. Included amont its edited selections are essays on the implications of the use of mathematical frameworks in academic

settings as well as examples of models that have been applied and/or developed. There are also three essays by scholar/administrators which serve to elucidate some important aspects of the bridge across the gulf between theory and technology.[28]

These individuals tend to focus on the context in which mathematical models might be applied and in doing so touch on values inherent in the application of techniques, practicality of information provided by these applications, and the degree to which necessary assumptions are met in the real world. Discussions of such issues lead to criticisms of such theoretical excesses as narrow views of models as strictly quantitative and tendencies to diverge too far from the real world which the theory was developed to explain.[29]

To sum up our search for connectedness, attempts to bridge the gap between mathematics and administrative theory are very infrequent in the literature. Theorists occasionally draw upon theories or models which have originated in mathematics or the sciences; even less often those who are identified with the mathematical technologies hark back to their roots in the humanities; writers who attempt to interpret the body of research for practitioners sometimes point out the need for theories which encompass both perspectives; and scholar practitioners point out the non-technical, soft, but theory-laden issues which arise when technologies are applied in the field.

A SEARCH FOR OTHER "HOMES" FOR THE QUANTITATIVE

Our odyssey through some domains where the two perspectives may meet has pointed out not only some key signs that such a meeting has taken place, but also some issues which are brought to the fore when both perspectives are present. These latter issues are likely to be left out of the discussion of separate perspectives and are therefore part of the void we identified in our analysis of exemplary works from each perspective.

The question remains, however, as to where mathematics fits into the make-up of a holistically prepared administrator and, consequently, where it fits into an educational curriculum designed to prepare such a person. What we have come up with is a smattering of useful insights, "ought-to-knows," and tenuous connections to the field. A more comprehensive app oach might be to approach the relevance of mathematics to administration in three of its incarnations--as tool, as metaphor, and as a style of thought.

Mathematics as Tool: Applied Mathematics

As alluded to previously, this is the manifestation of mathematics which has been most thoroughly mined for practitioners and scholars of educational administration, and is probably the area implied by the term "quantitative methods." Evidence of the usefulness of this aspect of mathematics can be classified into three distinct categories: applications to business functions, applications to program decisions, and applications in research.

Business Functions. These applications have probably hued most closely to the strict assumptions of the mathematical models and

produced results least likely to be questioned. Such examples as a linear programming model of a merit pay plan[30] and a linear programming solution to a desegregation decision[31] would fall under this category. Simulations of school busing plans are also carried out within this area.

Program Decisions. Applications in this area tend to get messy, satisfying neither the rigor of the mathematical model nor the needs of the decision-maker or her/his constituents. Unrealistic assumptions tend to be made which preclude the generation of a solution which can be applied to the very real problem. Examples such as the use of goal programming in higher education[32] and linear programming in planning the distribution of vocational programs across a state[33] appear in this category. A variant of linear programming, data envelopment analysis, has been found useful in evaluating effectiveness of programs or units and comparing the likely success of proposed programs.[34]

Research. Uses of mathematical models, outside of those considered in the study of statistics, in research have been few.[35] There are probably few people who consider these models as research tools. Yet the classic work on the garbage can model of organizational choice was based on an extensive mathematical simulation which flowed from assumptions of how decisions were made in university organizations.[36] Works on research strategies which can be used in the study of organizations include computer simulations as a viable alternative.[37]

As was mentioned earlier, the framework of operations research might be applied fruitfully to the solution of specific educational problems. Thus, it is a viable alternative to studies which seek to

confirm or disconfirm hypotheses and may be generalizable to large populations. Examples of such studies may be found in special education and reading.[38]

In none of the uses of mathematics as a tool, however, do we find a concern with what it is that makes the educational enterprise work. Yet this is a feature of applied mathematics.

> Applied mathematics is an intellectual discipline, not part of industrial technology. The ultimate goal of applied mathematics is action, to be sure, but, before that, applied mathematics is a part of theoretical science concerned with the general principles behind what makes planes fly and bombs explode.[39]

Or, we may add, what makes educational institutions function. Perhaps as we move into more abstract areas of mathematics we will find more direct connections to the educational enterprise.

Mathematics as Metaphor

The discussion most central to education may result from the use of math as metaphor[40] rather than satisfying the assumptions of specific mathematical models. Some suggestive examples follow.

Efficiency vs. Redundancy. An essay on the mathematics of language brought this dichotomy to my attention. It seems that a really efficient language would use all possible combinations of a minimum number of letters. Different languages vary in their efficiency, but none of them come anywhere near reaching an ideal. This is for a very practical reason, namely that a certain amount of redundancy, that is more letters and not all possible combinations being used, is necessary if the human mind is to remember different words and their meanings.[41]

Is there a parallel contrast of opposing ideals in education? Efficiency is a much-touted ideal especially during times such as the

present of tightening budgets, and there are those who oppose this ideal at some times more quietly than others but usually from a standpoint of humanity, that is how can we talk about efficiency when we're dealing with educating the minds of children, not stuffing sausages? But has anyone ever focussed the debate by identifying the issue as finding a point of moderation between two extremes on the same continuum?

Let me eludicate. Children are brought together in classrooms in order to make the teaching process more efficient. Extreme redundancy can probably be best exemplified by tutors employed by wealthy families to devote their entire attention to the education of a single child. Under this system, the tutor would have the opportunity to know this one student quite well and thus be responsive to her or his needs. The ideal of efficiency, which has probably never been attempted, let alone achieved, could be a system wherein each teacher was especially qualified to carry out a specific element of the educational process and groups of students in need of that particular element would be sent to the teacher for that specialization. This is rather like the role of medical specialists. Some suggest that this ideal could be approached by the use of computers for individualized instruction. The closest we currently come to this ideal at present, however, is in allowing teachers to specialize in certain subject areas and moving students to different teachers for exposure to the various disciplines. More and more this is being done at quite young ages.

What are the values of redundancy which are sacrificed under such a system? Clearly no one teacher knows the whole child in such a program--only the piece which relates, or fails to relate, to her or his

subject. What are the consequences of no one in the school knowing the whole child? Perhaps the recent movement toward "holistic" grading is an attempt to urge teachers to try to consider the whole child, but how many whole children is one teacher capable of getting to know well? In junior high schools where students may range all over the school to pick up their required learning, they can come into occasional contact with many adults and students who don't know them at all. This potentially alienating situation has been combatted in some schools by "family grouping" in which, for example, four classes of students might have the same four teachers for their basic subjects. Thus, between the four teachers there is a more whole knowledge of each student, and the teams of teachers might come together to help solve problems of individual students.

One of the essential differences between these systems of organizing learning is where they fall on the efficiency/redundancy continuum. However, since quantitative experts are busy applying and defending the doctrine of efficiency, to the exclusion of its opposite, redundancy, and non-quantitative scholars shy away from any mention of number, while at the same time feeling that something important is being overlooked, no one every engages in the debate with any notion of shared meaning. W. B. Yeats summed up the dilemma for the non-mathematician when recommending in a letter that his son learn mathematics:

> I know that Bertrand Russell must, seeing that he is such a featherhead, be wrong about everything but as I have no mathematics I cannot prove it.[42]

Familiarity with the mathematical concept of efficiency vs. redundancy would perhaps add to the administrator's facility in discussing this important issue.

Abstract vs. Concrete. The problem that mathematicians have in resolving these seemingly contradictory characteristics of their discipline may have been a factor contributing to the dilemma in which mathematicians in administration currently find themselves. In administration we have utilized primarily (almost exclusively) the concrete nature of mathematics. Our research and our teaching and our essays consist of explanations of specific applications to concrete problems. Nor are we alone in manifesting this phenomenon. In discussing the management sciences, Drucker argues that

> ...the management sciences began with the application of concepts and tools developed within a host of other disciplines for their own particular purposes....
>
> As a result, the focus of much of the work in the management sciences has not been on such questions as "What is the business enterprise?" "What is managing?" "What do the two do, and what do the two need?" Rather, the focus has been "Where can I apply my beautiful gimmick?"[43]

A consequence of this myopic concentration on concrete examples is a failure to develop a unique science of educational administration.

Drucker's criticism is more than vaguely reminiscent of a similar criticism of the research in educational administration as a whole:

> Whereas the literature is replete with myriad theories of organizations and is littered with attempts to understand schools through the various perspectives they afford, it is virtually bereft of serious attempts to describe or analyze schools themselves.

> ...Knowledge about administrative processes - decision making, motivation, supervision, communication, finance, policy making, and so on - is clearly necessary, but it will be of limited utility unless it can be placed within the context of a clear understanding of schools.[44]

Perhaps the marriage of some of the more micro studies such as those following the Mintzberg design[45] with a more abstract conception of mathematics could result in the birth of a true science of educational administration.

Mathematics as a Style of Thinking[46]

Along with a recent resurgence of interest in problem solving, the field of mathematics education has begun (at the fringes of the field) to concern itself with the concept of "mathematization." Though not well defined, the concept attempts to capture what is involved in mathematical thinking as opposed to mathematics as a body of knowledge.[47] The most radical statement of the concept asserts that anyone who speaks a native language already incorporates in his/her structure of the world a fundamental appreciation for mathematics thought. Being able to use words like "anyone," "each," "every" as well as being able to correctly use pronouns implies a deep appreciation for the concept of a variable. Being able to use correct grammar implies a fundamental understanding of the concepts of relation, set and operation.

A less radical statement would suggest that thinking is frequently exhibited in schematizations that make minimal use of formal and abstract language.

Above, for example is a picture of a geoboard, a wooden square with nails equally spaced as indicated. Anyone who can calculate the area of the region enclosed by the rubberband (forming a polygonal region as indicated) by mentally adding and subtracting congruent regions, in the absence of any area formula, not only has a fundamental appreciation for area (much as Euclid had--as opposed to modern-day misunderstandings of Euclid), but in addition has a basic understanding of the concept of equality and transformation.

Mathematization seems to be a mode of thinking applicable to a wide range of fields and consisting of operations, processes, and dynamics unique to this mode of thought. This mathematical thinking entails such operations as finding relationships and transformation by combination or substitution, processes like conjecturing and convincing; and such dynamics as manipulating and getting a sense of pattern. That it is most often <u>not</u> gleaned from a study of the content of the discipline of mathematics is clear from its failure to appear consistently even in students prepared to major in mathematics. However, I suspect that it is this aspect of mathematics rooted in abilities we utilize in everyday living which would be of most value to the administrator.

WHERE DO THESE EXPLORATIONS LEAD?

This essay has sketched the bare outlines of a dilemma--a gulf in the study of and writing on administration. I submit that this gulf imposes limitations on our views of inquiry into educational administration, as well as fails to integrate important elements of administration both of which are encompassed in the practice of administration. Thus, this dilemma would seem to me to be problematic in the area of thinking about administration for both those who practice inquiry and those who carry out administration in the field.

Attempts to bridge the gap in the theoretical literature in any deliberate way appear to be nonexistent. Literature geared toward practitioners seems to try to make sense of the mix by pointing out their linkages in practice, e.g. by discussions of the usefulness of technology for decision making or the intersection of values and objective data. However, little has been done to attempt to systematically explore possible bridging ideas which might serve to close the gap.

Three aspects of mathematics which have been or could be found relevant to administration were explored briefly--tools, metaphors, and styles of thinking. Introduction of tools into the literature and graduate classes has been primarily through a variety of nice examples and has been characterized by two approaches. There are those such as McNamara who would try to bring the administrator to an appreciation of the mathematics. Others such as Mann attempt to accomplish a similar task by bringing the mathematics to the administrator.

The kind of mathematization implied by metaphors and styles of thinking, however, suggest to me a different approach to the marriage of

the areas. That is, they both suggest an attempt to discover aspects of mathematics already inherent in the thinking about and practice of administration. Thus, the questions might become: How do the mathematical metaphors used in the reporting of research on administration serve to link theoretical and quantitative domains of the field? To what extent and in what way do mathematical styles of thought (not necessarily quantitative) occur in the day-to-day practice of educational administration? What sort of knowledge and appreciation of mathematics, if any, would be beneficial to those who practice inquiry and those who administer in the area of education? How can mathematical material be best taught in order to foster these relevant understandings and attitudes?

Whether such musings would help the public relations director with whose plight we initiated this essay is at this point moot. However, the reluctance with which many educators approach the study of mathematical topics would seem to indicate that, like her, many administrators may suffer from a reluctance to question facts stated in quantitative form. This possibility alone coupled with the increased availability and use of data, should serve to alert us to explore once again the place of mathematics in the general education of administrators.

Furthermore, our tentative exploration here would seem to indicate that search for the inherent mathematical ideas suggested in this discussion would promote our own understanding of the conduct of school administration. The concepts of mathematical metaphors and mathematization would seem to be especially provocative for new lines of inquiry and discussion.

NOTES

1. Some of the more general overviews include J. F. McNamara, "Mathematical Programming Models in Educational Planning," Review of Educational Research 41 (December 1971): 419-446; J. F. McNamara, "Mathematics and Educational Administration," Journal of Educational Administration 10 (October 1972): 164-183; and J. N. Johnstone, "Mathematical Models Developed for Use in Educational Planning," Review of Educational Research 44 (Spring 1974): 177-201. Examples of specific applications are also found in the journals of this period: J. E. Bruno, "Using Linear Programming Salary Evaluation Models in Collective Bargaining with Teacher Unions," Socio-Economic Planning Sciences 3 (August 1969): 103-117; J. E. Bruno, "An Alternative to the Use of Simplistic Formulas for Determining State Resource Allocation in School Finance Programs," American Educational Research Journal 6 (November 1969): 479-500; and J. F. McNamara, "A Mathematical Programming Approach to State-Local Program Planning in Vocational Education," American Educational Research Journal 8 (March 1971): 335-363. Texts, such as F. W. Banghart, Educational System Analysis (New York: Macmillan, 1969) and R. A. Van Dusseldorp, D. E. Richardson, and W. J. Foley, Educational Decision-Making Through Operations Research (Boston: Allyn & Bacon, 1971), also appear during this time.

2. These workshops were presented in conjunction with the American Educational Research Association Annual Meetings.

3. J. E. Bruno and J. N Fox, Quantitative Analysis in Educational Administration Preparation Programs (UCEA-ERIC Monograph Series, Columbus, Ohio: UCEA, 1973). Educational administration departments

across the country here budding specializations in research, planning, and evaluation existed were identified in this monograph.

4. This point is discussed in T. J. Peters and R. H. Waterman, Jr., In Search of Excellence: Lessons from America's Best-Run Companies (New York: Harper & Row, 1982): 32-33.

5. While discrete applications of specific mathematical models continue to appear in the scholarly journals (See, for example, A. M. Bessent and E. W. Bessent, "Determining the Comparative Efficiency of Schools Through Data Envelopment Analysis," Educational Administration Quarterly 16 (Spring 1980): 57-75; M. Doscher and J. E. Bruno, "Simulation of Inner-City Standardized Testing Behavior: Implications for Instructional Evaluation," American Educational Research Journal 18 (Winter 1981): 475-489; and T. W. Pullum and S. N. Graham, "Measuring the Implementation of Racial Balance Under Formal Constraints," Educational Evaluation and Policy Analysis 4 (Spring 1982): 109-117. I base my conclusions on two observations: first, of all these authors, only one, E. W. Bessent, identifies himself with educational administration; the rest are from operations research (A. M. Bessent), psychology (Doscher), education (Bruno), sociology and demography (Pullum), and computer programming (Graham). Second, only specific applications are appearing--no general overviews of mathematical applications or quantitative methods are found in the recent literature.

6. J. E. Bruno, "Linking Operations Research Methods and Standard Statistical Techniques in Educational Policy Analysis" (paper presented at the Annual Meeting of the American Educational Research Association, Los Angeles, April 1981).

7. R. I. Levin, C. A. Kirkpatrick, and D. S. Rubin, Quantitative Approaches to Management, 5th ed. (New York: McGraw-Hill, 1982).

8. R. Ebel, in "The Future of Educational Research," F. H. Farley, ed., Educational Researcher 11 (October 1982): 18-19.

9. The reason that the question of quantification inevitably occurs seems to me to be summed up in Ackoff's discussion of models in R. L. Ackoff, Scientific Method: Optimizing Applied Research Decisions (New York: John Wiley & Sons, 1962): 108-110. Here the most manipulable models, and those which are most generalizable to a variety of situations, are found to be symbolic; and those models in which the symbols represent quantities are matheratical. Hence the issue of quantification is inextricably entangled with the notion of generalizability, a central value in curriculum design if not in the actual practice of operations research.

10. The study of mathematics as applied to educational administration seems to go under the various headings of applied mathematics, quantitative methods, or operations research. At more advanced or general levels it may be denoted mathematical modeling. Since I am interested in a broader definition of mathematics and its applications to administration than those which are strictly quantitative, I will refrain from the use of the term mathematical models or any other term which suggests strict quantification.

11. While textbooks of the applied mathematics genre, such as Banghart, Educational System Analysis and Van Dusseldorp, et al,. Educational Decision-Making, provide illustrations of the techniques presented, attempts to provide exhaustive treatment of actual and potential applications are found primarily in essays such as the following: McNamara, "Mathematical Programming Models;" Johnstone, "Mathematical Models;" and J. F. McNamara, "Markov Chain Theory and Technological Forecasting," in Futurism in Education, S. P. Hencley and S. R. Yates, eds. (Berkeley, California: McCutchan, 1974), pp. 301-345.

12. An article which does provide a conceptual framework is McNamara, "Mathematics and Educational Administration." This essay is a serious attempt to move the applicability of mathematics in administration beyond quantitative methods. In it the author makes use of a mathematical vocabulary of symbols and a set of "grammatical rules for using the vocabulary," thus signifying that mathematics is another language the learning of which might provide a useful tool in educational administration (p. 165). The approach I am developing in this article differs from McNamara's in that, in addition to the benefits of an abstract language of mathematics, there may be mathematical elements extant in the existing language and practice of administration. Thus, my approach is closer to that of Mann who embeds a "calculating component" along with a "control component" within the policy arena, rather than trying to squeeze decision making into a mathematical frame. See D. Mann, Policy Decision-Making in Education: An Introduction to Calculation and Control (New York: Teachers College Press, 1975): p. 55.

13. The complete citations are P. F. Silver, Educational Administration: Theoretical Perspectives on Practice and Research (New York: Harper & Row, 1983), and G. C. Hentschke, Management Operations in Education (Berkeley, California: McCutchan, 1975). Books in the first category are much more numerous than those in the second, which is to be expected given the broad definition which I have given to the first category.

14. The reference cited in both books is H. J. Hartley, Educational Planning - Programming - Budgeting: A Systems Approach Englewood Cliffs, N.J.: Prentice-Hall, 1968). Authors cited in both books include: D. L. Clark and D. E. Griffiths for D. E. Griffiths, D. L. Clark, D. R. Wynn, and L. Iannacone, Organizing Schools for Effective Education (Danville, Illinois: Interstate Printers and Publishers, 1964) in Hentschke and D. E. Griffiths, ed., Developing Taxonomies of Organizational Behavior in Educational Administration (Chicago: Rand McNally, 1969) and D. L. Clark, "An Analysis of Research, Development, and Evaluation Reports on Exceptional Urban Elementary Schools. In Why Do Some Urban Schools Succeed? (Bloomington, Ind.: Phi Delta Kappa, 1980), pp. 171-190 in Silver; and L. K. Bishop for W. D. Wiley and L. K. Bishop, The Flexible Scheduled High School (West Nyack, N.Y.: Parker Publishing, 1968) in Hentschke and J. R. George and L. K. Bishop, "Relationship of Organizational Structure and Teacher Personality Characteristics to Organizational Climate," Administrative Science Quarterly 16 (December 1971): 467-475, L. K. Bishop and J. R. George, "Organizationl Structure: A Factor Analysis of Structural Characteristics of Public Elementary and Secondary Schools," Educational Administration Quarterly 9 (Autumn 1973): 66-80, and C. R. Steinhoff and

L. K. Bishop, "Factors Differentiating Preparation Programs in Educational Administration: UCEA Study of Student Organizational Environment," Educational Administration Quarterly 10 (Spring, 1974): 35-50 in Silver.

15. Silver, Educational Administration, pp. xiii-xiv.

16. Hentschke, Management Operations, pp. xi-xii.

17. Another interesting explanation for the completely different foci in these two books might be contained in the use of the word "administration" by Silver and "management" by Hentschke in the respective titles of their books. Cunningham and Payzant suggest that a study of the meanings and uses of these words in the field of educational administration would be useful for understanding the distinctions between them. See L. L. Cunningham and T. W. Payzant, Understandings, Attitudes, Skills and Symbols: Leadership in the Future (Columbus, Ohio: University Council for Educational Administration, 1983): p. 29, note 55.

18. The usefulness of the term "quantitative" is questioned by W. T. Morris, "Quantitative Methods - A Management Perspective," Industrial Engineering, 7 (June 1975): 43-47. He suggests that the label may contribute to the tendency to not go beyond superficial applications to a broader range of more analytical approaches.

19. Hentschke, Management Operations, pp. x-xi. For a similar discussion, see chapter one of J. E. Bruno, Educational Policy Analysis: A Quantitative Approach (New York: Crane, Russak & Co., 1976).

20. R. E. Callahan, Education and the Cult of Efficiency (Chicago: The University of Chicago Press, 1962).

21. See, for example, Adler's statement that "knowledge attained by the mathematician has extraordinarily wide and diverse applicability in other spheres of inquiry and branches of knowledge--in most, if not all, of the natural sciences and in many of the social sciences," M. J. Adler, "Knowledge Become Self-Conscious," The New Encyclopaedia Britannica, 15th ed., 1975, Propaedia, p. 692.

22. Silver, Educational Administration, Chapter 3.

23. Silver, Educational Administration, Chapter 2, pp. 21-22. Machematicians point out that the most interesting and vital use of axioms takes place in the "social, decision, and managerial sciences" where they "are often a very integral part of the early modeling process in theoretical approaches to many problems." In contrast, their use in mathematics and the physical sciences is confined to an organizing and summarizing role after discoveries have been made and tested. Thus, a more lively approach to their use in the pegagogy of mathematics courses would entail exposure to their constructive uses in the social sciences rather than the dry, simplistic, and summative applications to mathematical topics such as geometry. See W. F. Lucas, "Growth and New Intuitions: Can We Meet the Challenge?" in Mathematics Tomorrow, L. A. Steen, ed. (New York: Springer-Verlag, 1981): p. 63.

24. I. I. Mitroff and M. Turoff, "The Whys Behind the Hows," IEEE Spectrum 10 (March 1973): 62-71.

25. For excellent examples of these discussions, see G. Morgan, Beyond Method: Strategies for Social Research (Beverly Hills: Sage, 1983) and R. P. Gephart, Jr., "Status Degradation and Organizational Succession: An Ethno-methodological Approach," Administrative Science Quarterly 23 (December 1978): 553-581.

26. P. F. Drucker, Management: Tasks, Responsibilities, Practices (New York: Harper & Row, 1974). See especially chapters 40 and 44 for discussion of our two perspectives.

27. Ibid., p. 552.

28. See R. M. Cyert, "Management Science and University Management," R. H. Hall, "Contemporary Organizational Theory and Higher Education: A Mismatch," and F. E. Balderston, "Dynamics of Planning: Strategic Approaches and Higher Education," in J. A. Wilson, ed., Management Science Applications to Academic Administration (San Francisco: Jossey-Bass, 1981). D. C. Hoaglin et al., Data for Decisions:Information Strategies for Policymakers (Cambridge, Mass.: Abt Books, 1982) is a text which addresses these very issues raised by the scholar/practitioner for prospective administrators who do not plan to be technical specialists. Instead of step-by-step instructions on how to carry out the method or detailed explanations of cases in which the method was used, it provides practical explanations of the methods, examples of situations where the methods have been applied, and discussions of the strengths and weaknesses of the methods.

29. Specifically, Hall, "Contemporary Organization Theory," from his background in sociology, criticizes the non-usefulness of three current trends in organization theory goallessness, loose coupling, and uncertainty. He asserts that, while these conditions exist to some extent, it is the degree to which organizations have some clearly defined goals, possess coupling between units, and face some certainties that makes them manageable. Thus, he suggests, pursuit of questions in these more positive areas would be of greater use to the administrator.

30. Bruno, "Using Linear Programming."

31. Pullum and Graham, "Measuring the Implementation."

32. This example is discussed in Hentschke, Management Operations on pages 340 to 352.

33. McNamara, "A Mathematical Programming Approach."

34. Bessent and Bessent, "Determining the Comparative Efficiency" and A. M. Bessent et al., "Evaluation of Educational Program Proposals by Means of DEA," Educational Administration Quarterly 19 (Spring 1983): 82-107.

35. While the area of applied mathematics known as statistics appears also in many if not most research articles, it is seldom seen to describe or explain actual processes of organizations in education. Two exceptions to this narrow use of statistics may be found in the causal modeling approaches used to explain organizational contributions to school effectiveness by C. E. Bidwell and J. D. Kasarda, "School District Organization and Student Achievement," American Sociological Review 40 (February 1975): 55-70 and I. Biniaminov and N. S. Glasman, "School Determinants of Student Achievement in Secondary Education," American Educational Research Journal 20 (Summer 1983): 251-268.

36. M. D. Cohen, J. G. March, and J. P. Olsen, "A Garbage Can Model of Organizational Choice," Administrative Science Quarterly 17 (March 1972): 1-25. Doscher and Bruno, "Simulator of Inner-city," also employ this technique for research albeit with any eye toward solving a particular problem in testing rather than for the purpose of extending theory by attempting to explain behavior.

37. J. E. McGrath, J. Martin, and R. A. Kulka, Judgment Calls in Research (Beverly Hills, California: SAGE, 1982).

38. Ebel's comments on this topic in "The Future" were cited earlier. He makes reference to two examples: N. H. Azrin, "A Strategy for Applied Research: Learning Based by Outcome Oriented," American Psychologist 32 (February 1977): 140-149 and M. A. Wallach and L. Wallach, Teaching All the Children to Read (Chicago: University of Chicago Press, 1976).

39. P. R. Halmos, "Applied Mathematics Is Bad Mathematics," in Mathematics Tomorrow, p. 13.

40. L. A. Steez, ed., Mathematics Today: Twelve Informal Essays (New York: Springer-Verlag, 1978): 7.

41. H. Kucera, "The Mathematics of Language," in The American Heritage Dictionary, 2nd College Edition (Boston: Houghton Mifflin, 1982): 37-41.

42. J. Hone, W. B. Yeats 1865-1939 (New York: Macmillan, 1943): 450.

43. Drucker, Management, p. 509.

44. D. J. Allison, "Toward an Improved Understanding of the Organizational Nature of Schools," Educational Administration Quarterly 19 (Fall 1983): 8-9.

45. D. J. Willower, "Analogies Gone Awry: Replies to Hills and Gonn," Educational Administration Quarterly 19 (Winter 1983): especially p. 43.

46. I am indebted to Stephen I. Brown for referring me to the material on which this section is based. His comments on an early draft of this paper were also invaluable.

47. Some insightful discussions of this concept in the mathematics education literature may be found in D. Wheeler, "Mathematization Matters," For the Learning of Mathematics 3 (July 1982): 45-47 and L. Burton, "Mathematical Thinking" The Struggle for Meaning," Journal for Research in Mathematics Education 15 (January 1984): 35-49.